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Mapping city-to-city networks for climate change action: Geographic bases, link modalities, functions, and activity

Taedong Lee [a, *], Ha Yoon Jung [b]

[a] Department of Political Science, Yonsei University, Yonsei Ro 50 Seodaemun-gu, Seoul, South Korea
[b] Department of Area Studies, Ewha Womans University, Seodaemun-gu, Seoul, South Korea

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ABSTRACT

By forming city-to-city (C2C) transnational networks, cities can take action collectively against climate change. Interaction and collaboration among cities offers policymakers a chance to learn how other cities are conducting climate mitigation and adaptation measures. However, activities of C2C climate networks vary. By analyzing C2C climate networks, this study aims to identify and categorize C2C networks for climate change action, and to link the functions with levels of activity. To understand C2C climate-action networks, we suggest a framework for mapping C2C: geographic bases (domestic, regional, and global C2C), linking modalities (multilateral, and institution-led C2C), and functions (information exchange, networking, lobbying and funding, research, standards and commitments provision, and monitoring and certification). Based on this framework, we analyze the contents of C2C websites to assess current activities. We find that not all C2C networks are currently active. Statistical analysis and case studies suggest that C2C climate networks with advanced functions—such as lobbying, research, climate plans, and monitoring—are likely to actively engage with member cities. However, C2C cooperation focusing mainly on networking or information sharing is less likely to survive. Policy implications suggest that well-designed and advanced C2C networks with research and monitoring functions rather than simple networking functions can enable member cities to actively engage in climate policy cooperation.
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1. Introduction

Cities with concentrated infrastructure, economic activities, and populations leave large environmental footprints both on their own spaces and on surrounding areas. Due to these characteristics, cities are particularly vulnerable to climate change including extreme weather, floods, droughts, hot temperatures, urban heat island effects, and sea-level rises.

On the other hand, as underlined in this special issue, tangible climate solutions can come from cities. A variety of urban climate change experiments take place in cities across the world (Bulkeley and Broto, 2012). Cities have been places for innovation, increasing interconnection of people, and dealing with climate change and energy issues (Bouteligier, 2012).

Cities do not act alone to tackle climate change. Cooperative local actions for climate change occur beyond state borders. A variety of interactions—including learning, collaboration, and diffusion of innovations—enhance climate policies at the local level (Lee and Van de Meene, 2012). We refer to these interactions as city-to-city (C2C) cooperation for climate change action. For instance, the Connecting Delta Cities network is a network of delta cities, including New York, Rotterdam, Jakarta, Ho Chi Minh City, and others that facilitates climate adaptation cooperation for cities located in delta areas around the world (CDC, 2013). C40 is another example, with 91 affiliated cities that account for 25% of global GDP, one in twelve of the global population, and that have taken more than 10,000 actions to combat climate change (C40, 2017). The collective actions of cities in these networks, instead of a single city, can play a crucial role for mitigation as the special issue of this journal proposes.

Current scholarly and practical attention has focused on transnational climate governance (Abbott, 2012; Bulkeley et al., 2012; Roger et al., 2017). Emerging studies also look at the role of transnational climate governance for cities and local governments (Bansard et al., 2017; Betsill and Bulkeley, 2004; Bouteligier, 2012; Hakelberg, 2014). For instance, Hakelberg (2014) argues that transmunicipal climate governance plays a role as an arena for

* Corresponding author.
E-mail addresses: tdlee@yonsei.ac.kr (T. Lee), hayoonj@gmail.com (H.Y. Jung).

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climate policy diffusion and climate strategy adoption. By critically assessing the greenhouse gas (GHG) mitigation target of thirteen transmunicipal climate networks, Bansard et al. (2017) argue that transmunicipal climate networks are not yet ambitious (compared to the parties to the Paris Climate Agreement) or representative (their memberships consist of mostly North American and European cities). Despite the value-added contributions of previous research, studies on identifying and categorizing translocal climate governance have been scant. In addition, studies on the activity level of these networks have been rare while the survival of a network is a pre-condition for the network's impacts on an individual city's climate policies as well as for various roles, including the diffusion of local climate actions. To fill this gap and to contribute to this special issue on cities as the core of climate mitigation, we address the following questions: what are the characteristics and functions of translocal climate networks? Why do some C2C networks continue to be active, while do others cease to be active? How are the functions of C2C associated with their current activity? Answering these questions allows us to provide typology of C2C climate networks and to understand underlying attributes of network activities.

The aims of this article are to identify and categorize the attributes of C2C climate networks and to analyze how the identified attributes influence the activities of translocal climate networks. We collect data of 24 already-formed C2C networks and analyze these networks using hypothesis test analyses and case studies.

To this end, first, we identify three ways of mapping C2C: geographic bases (domestic, regional, and global C2C), linking modality (multilateral and institution-led C2C), and functions. Second, we apply this framework to categorize C2C climate networks. Third, we analyze which functions of networks enhance the level of activity.

Having a typology of C2C would be beneficial to enhance our understandings of different types and functions of translocal climate networks. It would also help cities identify and make choose their mode of participation and partnership with C2C networks.

2. City-to-city cooperation as horizontal translocal relations

City-to-city cooperation can be viewed from the theoretical perspective of translocal relations. Theories of translocal relations extend existing international relations studies by incorporating local authorities and other local actors as key actors in world politics. Translocal relations look at interactions between local actors (municipal authorities, local businesses, and local civil society organizations) and other local and international actors within and across national boundaries. A local actor is nested within the multi-tiered hierarchy that includes international, national, and regional jurisdictions. Despite the hierarchical attributes, a local actor also has autonomy to horizontally interact with other actors (Lee, 2015).

Among hierarchical and vertical attributes of translocal relations, C2C cooperation primarily takes place in horizontal governance. That is, C2C focuses more on local actors' interactions with other local actors within and beyond state boundaries. C2C cooperation activities encompass socialization, technological transfer, policy learning, business interaction, funding, standards provision, and many other forms. For instance, policy learning refers to the use of information and knowledge to make predictions, which are then used to make decisions (Bennett and Howlett, 1992). Policy learning is inherently relational. Actors seek to learn from other actors to upgrade their policy measures (Lee and Van de Meene, 2012). C2C climate networks provide a number of opportunities for learning, information sharing, and networking on climate change policies and strategies.

Another form of interaction is C2C collaboration. Collaborative activities encompass information, financial and human resource exchange, and common project development (Feiock et al., 2010). C2C collaboration can be facilitated by making networks for shared target, research, lobbying, funding, and monitoring climate policy performance (Lee, 2015).

3. Frameworks for classifying city practices in C2C

This study suggests analytic frameworks for comparing city practices. First, one way to compare C2C networks is based on geographic orientation: domestic, regional, and global scope. Second way is about linking modality: multilateral, and institution-led modes. Third method is to focus on different functions—such as information sharing, networking, research, target setting, funding, lobbying, and mitigation procedure—in order to categorize Climate C2C Climate networks. Particularly, we look at how different functions link to the activity level.

3.1. Geographic orientation

C2C for climate actions occurs within different geographic scopes. Some C2C cooperation on climate change action takes place at the national level. Another scope of C2C can be facilitated at a regional level. Other C2C cooperative activities arise at the global level. We identify the potential capacities and limitations of each type of C2C in cooperation on climate change issues.

3.1.1. Domestic C2C cooperation

Cities within the same country are likely to have more opportunities to cooperate with each other due to geographic proximity and cultural similarities such as language and history. However, it is also plausible that cities in the same country compete to gain more financial resources and better reputations.

The following are several strengths for domestic C2C in general, but for climate change action in particular. Geographic proximity could reduce the transaction cost of C2C cooperation (Rose, 1991). Similar cultural/institutional contexts could enhance cooperation among domestic C2C networks. Cultural similarity encompasses ways of living, communicating, and thinking (Child and Faulkner, 1998). Those cities that share a language reduce transaction costs of cooperation. In a similar vein, shared institutional contexts could breed links among cities. Cities in one country have mostly coherent legal and administrative frameworks. Despite cultural and institutional similarities, cities in the same country usually differ in terms of size, socio-economic conditions, and political conditions. In addition to socio-economic conditions, political differences, difference partisanship, may impede cooperation among cities. Mayoral partisanship (such as progressive versus conservative party affiliation) may influence the C2C cooperation behind the scenes. Considering strengths and weaknesses, domestic C2C facilitates cooperation by making use of cultural and institutional similarity and geographic advantage to reduce transaction costs of interactions. To overcome weaknesses, grouping by similar types, sizes, socio-economic conditions, and focus areas would be an effective strategy. Furthermore, coordination between local authorities and central governments for fair allocation of financial and human resources will reduce external threat factors and utilize opportunity factors (Parker and Rowland, 2007).

3.1.2. Regional C2C cooperation

Beyond nation-state boundaries, C2C cooperation takes place at the regional level. Beyond national boundaries, cities could choose a variety of partners for collaboration who have differences as well as similarities.

A primary strength of regional C2C is the scope and number of partnering cities. Regional C2C occurs across state borders in the region (e.g., Europe, Asia, North America). A variety of choices for partnership allows cities to find appropriate cooperative relations. However, regional C2C also has weaknesses. Since cities in these regional networks come from various countries, they speak different languages and have different institutional settings. This aspect tends to increase transaction costs for cooperation. In addition, different national institutions also impede efficient cooperation among cities in the regions. To foster regional C2Cs, increasing various regional partnerships provides benefits of cooperative relations among cities. In addition, close coordination with supranational institutions or the formation of coordinating regional institutions offers opportunities for cities participating in regional C2C.

3.1.3. Global C2C cooperation

Cities cooperate on climate change issues beyond the countries and regions they belong to. Participation and interaction takes place among cities globally. Cities have become important actors in global climate governance. In this regard, global C2C plays a significant role in enabling cities to interact with each other.

The strength of global C2C lies in its coverage. The scope and membership of global C2C transcends national and regional (usually continent-based) boundaries (Lee and Koski, 2014). In addition, there great potential for global C2C to respond to climate change issues. Despite the lack of state support, some cities have collectively tried to lead the way in reducing greenhouse gas emissions and sharing best practices beyond state boundaries (Parker and Rowland, 2007). Cities in global C2Cs share a variety of climate action experiments and policies, including climate financing, mitigation measuring, and risk adaptation.

Yet global C2C has weaknesses in the climate cooperation field. Compared to domestic and regional C2C, global cooperation requires more capacity and higher transaction costs. Many small and medium-sized cities, particularly in developing countries, may not have the financial and institutional capacity for consistent global cooperation (Bansard et al., 2017).

Furthermore, the existing international system poses a threat to the status of cities and global C2C networks. The state-centric international system gives nation-states the right to make legally binding international treaties. While cities may want to establish legally binding international agreements through global C2C networks, the hierarchical relationship between state governments and local authorities impedes such actions (Lee, 2015).

Strategies to enhance strengths of global C2C include expanding memberships at the global level. Broadening membership in the global pool gives cities opportunities to choose specific benchmarking points from cities around the world for developing their own policies. However, some cities lack the capacity to plan, implement, and cooperate on climate actions. Capacity building for these laggards should be one of the primary aims of global C2C.

3.2. Linking modality

Linking modality refers to the way of creating C2C ties.[1] There could be two different types of linking modalities: multilateral and institution-led C2C cooperation. Multilateral C2C cooperation refers to learning and collaboration between more than two cities. Multilateral C2C cooperation tends to be voluntarily initiated by city governments. Compared to multilateral C2C cooperation, institution-led C2C interactions are initiated by institutions other than city governments, including nongovernmental organizations (NGOs) and nonprofit organizations (NPOs). Each type of modality has its strengths and weaknesses.

3.2.1. Multilateral cooperation

Multilateral C2C cooperation refers to learning and collaboration among more than two cities. The difference between multilateral cooperation and institution-led cooperation is in the actors that initiate the cooperation; multilateral cooperation tends to be initiated by cities, whereas institution-led cooperation is mostly initiated by NGOs.

Leading cities in climate action form cooperative city networks such as C40, US Mayor Climate Protection Agreement, and Connecting Delta City network (CDC, 2013; Niederhafner, 2013). The emergence of multilateral C2C increases the visibility and influence of translocal governance in global climate politics (Lindseth, 2004). Each city may achieve emission reduction targets, if any, independently, but cities are forming multilateral C2C networks based on their principles and procedures. The strength of this type of cooperation lies in extended learning and sharing across cities worldwide. Multiple collaboration opportunities could emerge in multilateral C2C networks because a number of cities are participating in networked governance (Lee, 2015). In addition, regular meetings of mayors and policymakers also complement climate mitigation and adaptation efforts. Multilateral C2C has flexibility for maneuvering by allowing the member cities to participate voluntarily in a variety of city cooperation networks. The agendas are usually set by member cities' initiatives. There are also weaknesses to multilateral C2C. Critiques of multilateralism ask who governs, takes initiatives, and sets the agenda in the multilateral setting. For instance, C40 has a steering committee consisting of representative cities and an elected chairman who represents member city mayors. Without coordination of the steering committee and an elected leadership, the already loose connection among member cities is likely to get looser (Acuto, 2013).

3.2.2. Institution-led cooperation

Cooperation, in many cases, requires constant coordination, dialogue, and decision-making. An institution can play a pivotal role in harnessing organizational capacity and in its ability to work with other cities. In the form of an institution-led C2C, NPOs/NGOs make an effort to lead city cooperation.

The strength of institution-led C2C stems from several activities of the institution. An institution has a cross-cutting coordination role. In this sense, an institution seeks to listen to member cities' voices and bring them together to share best practices. Moreover, an institution such as ICLEI (International Council for Local Environmental Initiatives, Local Government for Sustainability) provides a standard for local authorities to follow (Betsill and Bulkeley, 2004; Reams et al., 2012). The Cities for Climate Protection program of the ICLEI suggests the five milestones of local mitigation policies: GHG emission inventory measurement; establishment of GHG emission reduction targets; setting a climate action plan; implementation of the action plan; and a monitoring, disclosure, and loopback process. With this procedure guideline, ICLEI provides a consultancy service for member cities. Institution-led C2C also promotes networking opportunities through workshops and case study publications on best practices.

Regarding weaknesses, as Betsill and Bulkeley (2004) pointed out, local government's limited capacity to tackle climate change is not the result of an absence of information or guidelines, but comes from a lack of resources and powers to act. If an institution cannot provide proper resources for implementing climate actions, policy learning through institution-led C2C could be minimal.

[1] Bilateral C2C is one form of translocal climate cooperation. However, this study focuses more of C2C networks, which consists of more than three cities.

3.3. Functions

From the perspective of functionalism, translocal climate networks are entities that facilitate the cooperation of cities across countries. Functions of a translocal climate network include information exchange/networking, lobbying, funding operations, research, target and plan provision (Niederhafner, 2013), and monitoring and certification (Bulkeley et al., 2012; Lee and Koski, 2015).

Information exchange/networking is one of the most common functions of C2C. Exchanging knowledge, best practices, and expertise is meant to reduce costs and enhance effectiveness of combatting climate change. A lack of proper knowledge of local-level climate policies drove cities to form networks, and thus provision and sharing of experience are the primary functions of the networks. To analyze the relationship between functions and activity, we coded information exchange if a C2C network provides climate-change-related policies and news through its website. The networking function is coded when a C2C network hosts meetings and conferences with member cities.

Lobbying upper-level (national and international) governments is another function of C2C networks. Lack of access of the city government to the national and international-level climate policymaking process drove cities to form their networks. Thus, cities and their networks aim to change upper-level governments by lobbying for their members' collective interests with upper-level governments. We coded lobbying as a primary function when a C2C network advocates change in climate change policy in international institutions or national governments.

Funding is an important function of translocal climate networks. Insufficient financial resources impede active response to the climate change issue. By forming, translocal climate networks acquire sufficient financial means to deliver planned actions. For instance, EU grants (for cities and member countries) often ask for the participation of six or more EU member states as a group. C2C could get the funding from upper-level governments by establishing cooperative networks of multiple participants. In a similar vein, C2C can be funded by private foundations such as the ACCCRN, which is funded by the Rockefeller Foundation. We coded funding as a function when a C2C network makes an effort to gain funding from international institutions, businesses, or foundations.

Research can be a key element of successful C2C cooperation. Documenting and disseminating research findings may bring about policy learning as well as a diffusion of best practices for member cities. C2C networks such as C40 provide cities with a substantial database for analyzing key trends, identifying opportunities for further action across the global network, and helping prioritize initiative areas with the potential for action and impact. When a C2C network offers research outcomes (rather than just simple news) of climate change policies, we code it as a research function.

Target and plan provision means that a C2C network (usually as a form of secretariat) suggests a standard or agenda to follow. Standards range from a simple commitment for membership, sharing reduction targets and plans, to following procedural standards such as ICLEI's five milestones (Giest and Howlett, 2013). We coded targets and climate change action plans if a C2C network provided a common mitigation target or voluntary target setting, and planning procedure respectively.

Monitoring and certification is to assess a compliance process of targeted goals by disclosing the information. This monitoring verifies members' activities and, in some cases, provides certificates for the accomplishment. Information disclosure is one of the ways to ensure compliance (Kraft et al., 2011). Certification provision enhances reputational benefits of being a member (Bartley, 2003). We coded the monitoring and disclosure function when a C2C requests member cities to monitor and disclose the mitigation performance in their websites.

4. Case assessments

The purpose of networking for a member city is to identify objectives and targets, to share information and best practices, and to reach common goals. Cities with these purposes interact with each other to exchange information, lobby, fund, provide standards, and monitor and certify through developing various types of translocal climate networks. "Networking" essentially comprises virtual and or real interaction and collaborative decision-making (Keiner and Kim, 2007). Actually, many C2C networks are in operation at the domestic, regional, and global levels, influencing the diffusion of climate actions worldwide. However, not all C2C networks are still in operation. Which C2C networks are active and which are not?

We analyze the contents of 24 already-formed C2C networks to find out their current active status by examining activities and organizational structures through analyzing their websites. The 24 C2C network cases were selected from existing literature (Bansard et al., 2017; Hakelberg, 2014; Niederhafner, 2013; Michaelowa and Michaelowa, 2016) and through searching websites linked to the C2C networks.

These include ACCRN (Asian Cities Climate Change Resilience Network), C40 (The C40 Cities Climate Leadership Group), Climate Alliance, Covenant of Mayors, ICLEI, and so many more (See Table 1 and Appendix for the detail information). Bilateral C2C networks are excluded from the cases due to the lack of formal homepages.

Among the 24 C2C Climate networks studied, there are two domestic (8.3%), eight regional (33.3%), and fourteen global (58.3%) networks. Regarding linking modality, ten C2C networks are multilateral (41.6%), and fourteen networks are institution-led (58.3%).

First, we recognize what activities C2C networks are engaged in by focusing on the current events. These networks mainly hold forums or meetings, planned projects, promoted partnership, conducted research, and so on. It is necessary to involve all the stakeholders in negotiating to address transnational issues, because these provide timely and important expertise and give legitimacy to the process (Reinicke and Deng, 2000). Meetings and events providing communication and information exchange platforms are planned on a regular basis. The intangible outcomes of networks—greater trust between participants and the creation of a forum for raising and discussing new issues—are often as important as the tangible ones (Keiner and Kim, 2007).

Fig. 1 shows that C2C networks mostly focus on information sharing (provision of climate-change-related information) and networking (hosting and participating in meetings and conferences) rather than lobbying, funding, and research. Among mitigation procedures, few networks set common GHG emissions mitigation targets; fewer networks provide monitoring schemes and information.

To address our research questions on network activity, we compare the mean difference of activity by different functions. Table 2 presents the two-sample t-test outcomes. While there are many networking C2Cs, the degree of activity is relatively low. Instead, C2C networks that have the functions of research and lobbying are likely to have higher levels of activity. Regarding the climate change mitigation function, there is no difference in active status between C2C networks with common target setting (such as 20% GHG emissions reduction by 2030) and those without. However, those C2C networks with advanced mitigation procedures such as plans and monitoring steps are all active. This implies that advanced functions of C2C networks are likely to facilitate current activities. On the other hand, C2C networks with simple functions,

Table 1
Mapping C2C networks (modality, region, functions (in parentheses), and active status (in **bold**)).

	Domestic	Regional	Global
Multilateral	- **US Mayor Climate Protection Agreement (research)**	- **EUROCITIES Declaration on Climate Change (standard)** - **Climate Alliance of European Cities with Indigenous Peoples (networking)** - **Energy Cities (networking)** - **Western Climate Initiative (networking)**	- **C40 (networking, monitoring)** - **Connecting Delta City (networking)** - Delta Alliance (networking) - World Mayors' Council on Climate Change (networking) - International Solar Cities (networking)
Institution-led	- **The Climate Registry standard, monitoring)**	- **Covenant of Mayors (standard)** - **ACCRN (Funding, information)** - Kitakyushu Initiative for a Clean Environment (Networking) - **Clean Air Asia (Networking)**	- **ICLEI CCP (Standard)** - **Carbon Disclosure Project (Monitoring)** - Slim City Initiative (Networking) - **United Cities and Local Governments (Networking)** - Connected Urban Development (Networking) - **The Climate Group (Networking)** - Community Development Carbon Fund (funding) - **Renewable Energy and Energy Efficiency Partnership (funding)** - **Sustainable Cities International (networking)**

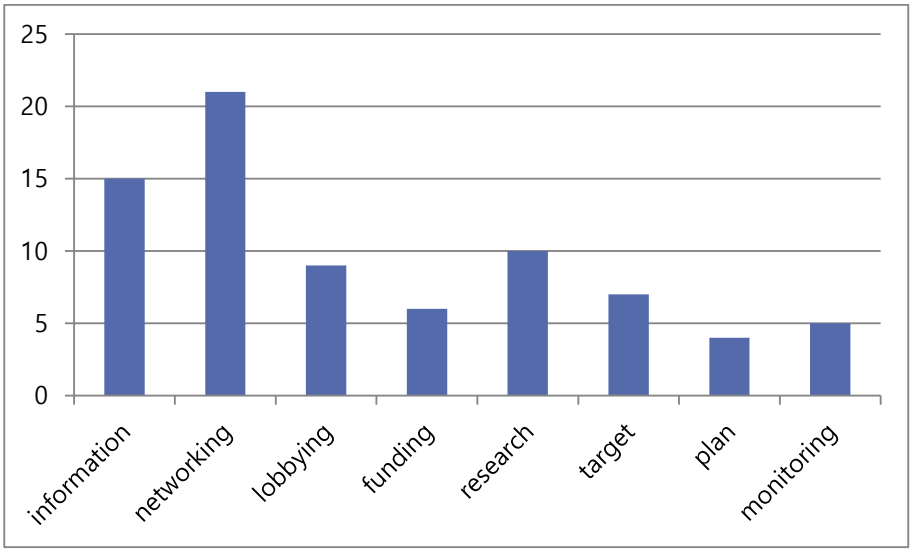

Fig. 1. Functions of C2C climate networks.

Table 2
C2C activity by different functions (the two-sample t-test outcomes).

Functions		Observations	Means of activity	T
Information sharing	No information sharing	9	.55	−1.26
	Information sharing	15	.8	
Networking	No networking	3	1	1.17
	Networking	21	.66	
Lobbying	No lobbying	15	.53	−2.68**
	Lobbying	9	1	
Funding	No funding	18	.77	1.28
	Funding	6	.5	
Research	No research	14	.5	−3.02**
	Research	10	1	
Target	No target	17	.70	-.03
	Target	7	.71	
Plan	No plan	20	.65	−1.40†
	Plan	4	1	
Monitoring	No monitoring	19	.63	−1.63†
	Monitoring	5	1	

Note: Levels of significance are denoted as follows: †$p < .10$ *$p < .05$, **$p < .01$ (one-tail test).

such as networking, are less likely to survive.

Our analysis shows that networks having the functions of research and lobbying are likely to have higher level of activity. This means that the research and lobbying functions can facilitate the implementation of climate change policies by increasing the possibilities of policy learning among member cities. These functions also increase the number of contacts with international institutions or national government to change policies.

To examine the relationship between functions and activities of networks, we conduct brief case studies. We selected four cases of C2C networks that vary in terms of different geographic orientations, linking modality, and functions. Four cases are selected because there are the variations in the dependent variable (currently active or not) and key independent variable (function). By controlling other independent variables (linking modality and geographic base), we aim to reveal the effects of the level of functions on activity of C2C networks. These cases include EUROCITIES Declaration on Climate Change, The Climate Registry, the World Mayors' Council on Climate Change and SlimCity Initiative. Former two cases show climate mitigation and adaptation activities in operation, and the latter two are inactive cases.

EUROCITIES Declaration on Climate Change is the case of multilaterally formed at the regional level. EUROCITES Declaration is the fruit of work by a group of 20 European cities entrusted by the Executive Committee of EUROCITES, the network of major European cities in some 34 European countries. The Declaration reflects the commitment of EUROCITES to fight against climate change. It outlines cities' commitment to reducing emissions through energy efficiency, one of the priorities of EUROCITIES agenda. Also, EUROCITIES has a number of working groups under its umbrella, one of which is the working group for environment that addresses climate change and energy efficiency issues. The working group monitors and responds to the EU strategy for climate adaptation, exchanges knowledge and best practices on climate mitigation and adaptation initiatives, launches 'the Green Digital Charter' providing a framework to use ICT as a main driver to improve energy efficiency, holds a number of regular and irregular events and forums, and publishes documents on climate change and energy efficiency. EUROCITIES working group for the environment provides member cities with the opportunity of information exchange, networking, lobbying, research, and providing standards in terms of the climate change.

The Climate Registry is the case of institution-led cooperation at the domestic level. The Climate Registry is a non-profit organization governed by American states and Canadian provinces. It designs and operates voluntary and compliance GHG reporting programs and assists organizations in measuring, reporting, and verifying carbon emission levels in order to manage and reduce it. Hundreds of organizations, such as corporations, universities, and local and state government agencies, report their emissions to the Climate Registry program. It also consults with governments nationally and internationally on all aspects of GHG measurement, reporting and verification. The Climate Registry runs project, named The Cool Planet Project, which provide utility company business customers assistance in measuring and managing their energy and carbon output. The Climate Registry is the case that has functions of standard provision and monitoring with expertise.

Two cases of EUROCITIES Declaration on Climate Change and the Climate Registry are instances of influencing higher level of functions on C2C networks activation. It implies that activation of C2C networks depends on research, target provision, monitoring functions to keep in contact with member cities such as conducting survey, and make member cities implement their commitment. These can lead to policy learning, benefit or shaming effects to member cities.

Those two cases above are the activities in operation, however, the following two are the cases of inactivity. The World Mayors' Council on Climate Change is the case of multilateral cooperation at the global level. The World Mayors Council on Climate Change is an alliance of committed local government leaders. The Council was founded in 2005 and has over 80 members consisting of Mayors and equivalent leaders of municipal levels of government. The objectives of the Council are to strengthen leadership on global sustainability and to be the prime political advocacy force of cities on global sustainability matters, by showcasing local leaders' climate actions, supporting its members to enhance their climate leadership capacities, addressing global climate policy makers, and politically steering the development and implementation of mechanism. For these objectives, the Council received technical and strategic support from ICLEI. The Council was successful in drafting Mexico City Pact that tries to measure and verify local climate action in 2011, creating carbon/Climate Registry (cCR). However, networking and information sharing functions did not advance monitoring or verification functions in the Council. Since the Climate Summit 2014 as a last gathering, the Council has not held meetings or events, conducted activities, or updated news.

SlimCity Initiative is the institution-led network at the global level. This Initiative was led by the World Economic Forum as an Industry Partnership initiative that provides a risk-free marketplace for cities and the private sector to exchange best practices and deliver resource efficiency within cities worldwide. This exchange focuses on the sustainable development of a city to achieve reduced carbon emissions and increased resource efficiency across all sectors, and involves industries such as chemical, engineering and construction, energy, information technology, mobility, and real estate. The Initiative brought together senior public-sector figures and comprises cross-sector themes such as smart energy, sustainable buildings, and the future of urban mobility. SlimCity Initiative functions as an information sharing platform. The Initiative developed a city issues survey, launched the edition of the SlimCity Knowledge Cards, and held several workshops using SlimCity Knowledge Cards and concepts to bring together local policymakers, the private sectors, experts, civil society members, and key community stakeholders. However, there were no visible activities except for publishing a report since 2009.

These two cases of The World Mayors Council on Climate Change and SlimCity Initiative show that C2C networks cannot be active only by providing networks and information functions. member cities and their officials cannot be incentivized to maintain their membership of a network by only adding to their load of information and meetings.

The case study of C2C networks shows that geographic orientation and linking modality are relatively irrelevant to activation of networks. Instead, if the C2C networks are built upon well-designed high-level functions such as research, standard provision, and monitoring, the possibility of activity and sustainability of networks can be increased.

5. Conclusion

The type and function of the C2C networks in a horizontal governance affect its operation, and member cities determine the best practices through relationship and collaboration, which in turn increase the likelihood of climate policy implementation. Developing C2C is meant to strengthen collective and global urban climate governance (Bontenbal, 2009). It also spreads best practices and collaborative opportunities between the private and public sectors. Various translocal networks for C2C climate action can, through cooperation, provide co-benefits for citizens and businesses. Interaction and collaboration among cities gives each city a

chance to learn how other cities are conducting energy efficiency and waste management measures for climate mitigation. To this end, well-designed C2C network aims and functions are required.

In this study, we asked if these collective actions of cities through C2C lead the way in tackling climate change problems? While there are burgeoning city networks for climate actions, not all C2C networks are active. Some networks do survive; others have faded out. This study suggests that the function of networks matters for activities. Despite the importance of networking and information sharing, it is important to enhance C2C cooperation from talking and networking into substantive action such as lobbying, research, and monitoring of the mitigation and adaptation performance. Otherwise, networking C2C cooperation may cease to exist.

To understand C2C climate networks, this study first outlines different forms of C2C cooperation: geographic base, linking modality, and functions. Each format has its own strengths and weaknesses. Institution-led C2C platforms, for instance, tend to share information and networking. Global C2Cs take advantages from broad coverage and various climate action experiments. Through mapping, categorizing, and analyzing 24 existing C2C networks in this article, we reached this conclusion. First, C2C networks conduct functions including information exchange, networking, lobbying, funding, research, target setting and planning, and monitoring and certification. Among these functions, exchanging information and networking are the most common type of functions. Second, in relating the functions to the activity of C2C networks, functions that C2C networks perform including research, lobbying, planning and monitoring enable C2C networks to actively engaged in urban climate policy and let them survive. Third, the result of comparing four cases of C2C networks indicates that C2C networks with advanced functions are likely to be active and sustainable. To sum up the findings of this article, the possibilities of implementation and effectiveness of climate mitigation would be increased among member cities when networks conduct advanced functions rather than simply networking and information exchange.

We can derive the following implications through analyzing C2C networks. The first implication is regarding the institutional design of C2C networks. When designing and forming the C2C networks, it is critical to decide which functions the network aims to provide for the member cities. There are burgeoning C2C networks on climate change and environmental cooperation. Simple information sharing or meeting opportunity through the network may not be enough. Based on our findings in statistical analysis and case studies, we suggest that the provision of specific and advanced functions, including research and monitoring, can attract cities' active participation in the networks and also help the survival of the network itself.

The second implication is for cities. As our typology presents, C2C networks for climate change action vary in terms of geographic focus, linking modality, and functions. Each type of C2C network has its strengths and weaknesses. Depending on the city's priority, purpose, and resources, it can choose a C2C network to facilitate local climate change actions. Based on our research we also suggest that a city that would join a C2C climate network would need to consider the advanced functions such as monitoring, standardization, and research as membership criteria rather than basic information sharing and networking functions.

This study contributes to our understanding of cities' collective action through C2C networks. It is also a contribution to the journal's special issue theme that focuses more on single cities' mitigation efforts. As theories and practices have shown, collective actions do not always work. We provide a framework of analysis that categorizes C2C climate networks and shows why some networks are activate and others are not. By empirically identifying and analyzing most of regional and global C2C climate networks, we suggest that institutional design and advanced functions such as lobbying, monitoring, and research are the key factors for collective actions of cities' climate actions in networks. We also expect that our findings could help cities to choose and join C2C networks to enhance their local climate action through cooperation.

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Appendix. List of C2C networks and activities

C2C Networks	Functions	Activities (focusing on the current events)	Website URL	Homepage Activation
Asian Cities Climate Change Resilience Network (ACCRN)	information, networking, lobbying, research	Forum Blog competition Building coalition/partnership	http://www.acccrn.org/	O
C40 Cities	information, networking, funding, research	Mayors Summit Research	http://www.c40.org/	O
Carbon Disclosure Project (CDP)	lobbying, monitoring, research	Operating global disclosure system Providing information to the market	https://www.cdp.net/en-US/Pages/HomePage.aspx	O
Clean Air Asia	information, networking, funding, plan	Integrated program Cities partnership Transport data for policies and investment planning	http://cleanairasia.org/	O
Climate Alliance of European Cities with Indigenous Peoples	information, networking, lobbying, target	International Climate Alliance Conference and General Assembly	http://www.climatealliance.org/	O
Community Development Carbon Fund	networking, funding	Extending the benefits of carbon finance to the poorest countries and poor communities	https://wbcarbonfinance.org/Router.cfm?Page=CDCF	Not very active
Connected Urban Development	information, networking, funding	Networking expertise of bringing information to users	http://www.cisco.com/web/about/ac79/ps/cud/about.html	Not active
Connecting Delta Cities			http://www.deltacities.com/	

(*continued*)

C2C Networks	Functions	Activities (focusing on the current events)	Website URL	Homepage Activation
	information, networking, research	Developing a network of delta cities (No CDC-led conference or workshop since 2014)		O (only news updated)
Covenant of Mayors	networking, lobbying, target, monitoring, research	Covenant of Mayors webinar Forum Workshop Action Plans of the cities	http://www.covenantofmayors.eu/index_en.html	O
Delta Alliance	information, networking, monitoring, research	Workshop, seminar, conference, training (No event updated since September 2014/ No newsletter updated since August 2015)	http://www.delta-alliance.org/	O (only news updated)
Energy Cities	networking, lobbying, research	Annual conference Initiatives & Campaigns Project Workshop Webinars	http://www.energy-cities.eu/	O
EUROCITIES Declaration on Climate Change	networking, lobbying, target, research	European Conference on Sustainable Cities & Towns International Cities for Mobility Congress Forums Working group	http://www.eurocities.eu/eurocities/priorities/climate	O
ICLEI- Local Government for Sustainability	networking, lobbying, target, research	Compact of Mayors E-Learning Webinar Resilient Cities Local Climate Solutions for Africa: Water & Climate Congress	http://www.iclei.org/	O
International Solar Cities	Networking	Congress	http://www.iscicities.org/	Not very active
Kitakyushu Initiative for a Clean Environment	information, networking, target	No events and announcement updated since 2010	http://kitakyushu.iges.or.jp/	X
Renewable Energy and Energy Efficiency Partnership (REEEP)	information, funding	Renewable Energy Africa Investment Summit World Energy Congress	http://www.reeep.org/	O
SlimCity Initiative	networking, funding	Most events are held by the World Economic Forum	https://www.weforum.org/reports/slimcity-cross-industry-public-private-initiative-urban-sustainability/	Not active
Sustainable Cities International	information, networking, research	International Youth Internship Program SCI Energy Lab	http://sustainablecities.net/	O
The Climate Group	information, networking, lobbying	Climate and energy initiatives with businesses and governments	https://www.theclimategroup.org/	O
The Climate Registry	information, target, monitoring	Climate Leadership Awards and Conference	http://www.theclimateregistry.org/	O
United Cities and Local Governments (UCLG)	information, networking, lobbying	UCLG Congress, World Summit of Local and Regional Leaders	www.uclg.org/	O
The US Mayor Climate Protection Agreement	information, networking, target, research	Agreement of Mayors in the US Reports/Latest News (Mayors Climate Protection Center)	https://www.usmayors.org/mayors-climate-protection-center/	O
Western Climate Initiative	information, networking	Board of Directors meeting	http://www.wci-inc.org/	O (only news updated)
World Mayors Council on Climate Change	networking	No events and news updated since 2014	http://www.worldmayorscouncil.org/home.html	X

References

Abbott, K.W., 2012. The transnational regime complex for climate change. Environment and Planning C. Govern. Pol. 30, 571–590.

Acuto, M., 2013. Global Cities, Governance, and Diplomacy. Routledge, New York.

Bansard, J.S., Pattberg, P.H., Widerberg, O., 2017. Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. International Environmental Agreements: Politics. Law Econ. 17, 229–246.

Bartley, T., 2003. Certifying Forests and Factories: States, Social Movements, and the Rise of Private Regulation in the Apparel and Forest Products Fields.

Bennett, C., Howlett, M., 1992. The lessons of learning: reconciling theories of policy learning and policy change. Pol. Stud. 25, 275–294.

Betsill, M.M., Bulkeley, H., 2004. Transnational networks and global environmental governance: the cities for climate protection program. Int. Stud. Q. 48, 471–493.

Bontenbal, M.C., 2009. Strengthening urban governance in the South through city-to-city cooperation: towards an analytical framework. Habitat Int. 33, 181–189.

Bouteligier, S., 2012. Cities, Networks, and Global Environmental Governance: Spaces of Innovation, Places of Leadership. Routledge, New York.

Bulkeley, H., Andonova, L.B., Backstrand, K., Betsill, M., Compagnon, D., Duffy, R., Kolk, A., Hoffmann, M.J., Levy, D., Newell, P., Milledge, T., Pattberg, P., VanDeveer, S.D., 2012. Governing climate change transnationally: assessing the evidence from a database of sixty initiatives. Environment and planning C. Government and Policy 30, 591–612.

Bulkeley, H., Broto, V.C., 2012. Government by Experiment? Global cities and the governing of climate change. Trans. Inst. Br. Geogr. 38, 361–375.

CDC, 2013. Connecting Delta Cities. CDC, Rotterdam.

Child, J., Faulkner, D., 1998. Strategies of Co-operation: Managing Alliances, Networks and Joint Ventures. Oxford University Press, Oxford.

Feiock, R., Lee, I.W., Park, H.J., Lee, K.-H., 2010. Collaboration networks among local elected officials: information, commitment, and risk aversion. Urban Aff. Rev. 46, 241–262.

Giest, S., Howlett, M., 2013. Comparative climate change governance: lessons from european transnational municipal network management efforts. Environ. Pol. Govern. 23, 341–353.

Hakelberg, L., 2014. Governance by diffusion: transnational municipal networks and the spread of local climate strategies in Europe. Global Environ. Polit. 14, 107–129.

Keiner, M., Kim, A., 2007. Transnational city networks for sustainability. Eur. Plann. Stud. 15, 1369–1395.

Kraft, M.E., Stephan, M., Abel, T.D., 2011. Coming Clean: Information Disclosure and Environmental Performance. The MIT Press, Cambridge.

Lee, T., 2015. Global Cities and Climate Change: Translocal Relations and Environmental Governance. Routledge, New York.

Lee, T., Koski, C., 2014. Mitigating global warming in global cities: participation and climate change policies of C40 cities. J. Comp. Pol. Anal. 16, 475–492.

Lee, T., Koski, C., 2015. Mulilevel governance and urban climate change mitigation. Environ. Plann. C 33, 1501–1517.
Lee, T., Van de Meene, S., 2012. Who teaches and who Learns? Policy learning through the C40 cities climate network. Pol. Sci. 45, 199–220.
Lindseth, G., 2004. The cities for climate protection campaign and the framing of local climate policy. Local Environ. 9, 325–336.
Michaelowa, K., Michaelowa, A., 2016. Transnational climate governance initiatives: designed for effective climate change mitigation? Int. Interact. 43, 129–155.
Niederhafner, S., 2013. Comparing functions of transnational city networks in Europe and Asia. Asia Eur. J. 11, 377–397.
Parker, P., Rowland, I., 2007. City partners maintain climate change action despite national cuts: residential energy efficiency programme valued at local level. Local Environ. 12, 505–517.
Reams, M.A., Clinton, K.W., Lam, N.S.N., 2012. Achievement of climate planning objectives among US member cities of the international Council for local environmental initiatives (ICLEI). Low Carbon Econ. 3, 137–143.
Reinicke, W., Deng, F., 2000. Critical Choices: the United Nations, Networks and the Future of Global Governance. International Development Research Council, Toronto.
Roger, C., Hale, T., Andonova, L., 2017. The comparative politics of transnational climate governance. Int. Interact. 43, 1–25.
Rose, R., 1991. What is lesson-drawing? J. Publ. Pol. 11, 3–30.